NOBANIS - Invasive Alien Species Fact Sheet

Anguillicola crassus

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Species description

Scientific names: *Anguillicola crassus,* Kuwahara, Niimi and Itagaki 1974
Synonyms: -

Common names: Eel swimbladder nematode (GB), Ålens svømmeblære nematod (DK), Simblåsemask eller Ålnematod (SE), Schwimmblasenwurm (DE), Angwilikola (PL), Sundmagaormur (IS).

Fig 1. *Anguillicola crassus*, photo by Marianne Køie.

Species identification
Adult nematodes have a body covered by a soft, wrinkled outer cuticle. The circular mouth opening is small surrounded by 4 dorsolateral and ventrolateral cephalic papillae and 2 small lateral amphids. The anterior rim of the buccal capsule bears one row of 22, 24, 26 or 28 circumoral teeth. The oesophagus appears strongly muscular, consisting of 3 lobes, expanding at its posterior half; anteriorly, the oesophagus forms 6 slightly elevated, rounded lobes protruding into the buccal cavity. The valvular apparatus of the oesophagus is well developed. Male worms have 6 pairs of caudal papillae; 2 praeanals, 1 or 2 adanals and 2 or 3 postanals. The overall body length of males is 20-60 mm with females measuring 47-71.5 mm. Body width of males is .9-2.8 mm and 3-5.6 mm for females (Taraschewski *et al.* 1987). Prominent cone-shaped vulva in posterior part of body. Mature females with white uterus occupying most of the body, containing numerous eggs, developing embryos and 250 µm long sheathed larvae (Moravec 1994).

Native range
Anguillicola crassus originated in Southeast Asia, and its natural host is the Asian eel, *Anguilla japonica* (Kuwahara *et al.* 1974; Taraschewski *et al.* 1987). Related species are also found in New Zealand and Australia (van Banning 1991, Moravec and Taraschewski 1988, Køie 1991).

Alien distribution

History of introduction and geographical spread.
Anguillicola crassus probably arrived in Europe with eels imported from south-eastern Asia (Höglund *et al.* 1989), possibly from Taiwan at about 1980 (Køie 1991). Within a few years, heavy infestations of the European eel (*Anguilla anguilla*) were reported. It was found in open water of the Weser-Ems River region in Northern Germany and in North Italian culture facilities in 1982 (Neumann 1985, Peters and Hartmann 1986). This nematode successfully colonised most European countries throughout the 1980s, especially in freshwater environments (Ashworth and Blanc 1997). The species was found in Germany in 1982. It successfully colonised most European countries throughout the 1980s, especially in freshwater environments (Køie 1991, Ashworth and Blanc 1997). In Denmark, the parasite was first observed in 1986 (Køie 1988), in Sweden in 1987 (Höglund *et al.* 1989). In Norway, the first infected eels were caught in 1993 (Mo and Steien 1993). In Latvia *A. crassus* was first discovered in lake Usmas and river Venta in 1998, and the parasite was found in all of the examined eels (Kirjusina and Vismanis 2004). *A. crassus* was imported to Estonia with young eels in the middle of the 1980s. In the early 1990s *A. crassus* was distributed practically all over the coastal zone of Estonia (Henn Ojaveer, pers. comm.).

The first observation of *A. crassus* in Sweden was in the artificially heated waters outside the nuclear power-plant Oskarshamn, on the east coast. The parasite rapidly became well established not only in thermal discharge areas but also in other brackish waters, as well as in some freshwater lakes (Wickström *et al.* 1998). In comparison with localities affected by thermal discharges, the infection rate in monitored inland (two sites), and coastal (one site) eel stocks has been much slower. As in Denmark, dispersal by man is believed to have greatly contributed to the further dispersal of the species. According to Wickström *et al.* (1998), there are strong indications that the parasite was introduced into several freshwater lakes as a result of stocking infected wild eels caught on the Swedish west coast.

In Denmark *A. crassus* was probably first introduced to the brackish Ringkøbing Fjord through trade with the Netherlands. Its further dispersal was probably mediated by man, rather than by natural migration (Boëtius 1989). According to Boëtius (1989) almost all of the [early] infections can be traced back to the Ringkøbing Fjord (Jutland). Introduction to Denmark probably took place some time before the first observation in1986, and within a few years, the parasite was present in several other locations in Jutland and on Zealand.

A. crassus was probably introduced to Estonia with young eels (SI 20-30 cm) from Germany in autumn 1989. In Lake Võrtsjärv the mean infestation rate was 44% (range in 22-71% in different length groups, *n*= 141, SI 50-91 cm) in 1994-97. The mean number of *A. crassus* per infested eel was 24, the maximum 92. (Ojaveer *et al*. 2003)

Pathways of introduction
The main dispersal vector is believed to be the uncontrolled intercontinental transfer of live eels, including stocking in natural waters (Køie 1991).

Alien status in region
Since its introduction in 1982, *Anguillicola crassus* has become firmly established in eel populations in fresh and brackish waters in most European countries (Køie 1991, Eno *et al.* 1997), see also table 1.

In Germany, eel populations are infected already from 65% to 90% with *A. crassus* (Deutscher Bundestag 2004). In eels of the river Rhine the average infection intensities amounted to 6 nematodes per swim- bladder (Wurtz *et al.* 1998). Surveys in other aquatic habitats even revealed average infection intensities of up to 12 nematodes per swimbladder (Leuner 2004).

Country	Not found	Not established	Rare	Local	Common	Very common	Not known
Denmark					X		
Estonia				X			
European part of Russia				X			
Finland	X						
Faroe Islands	X						
Germany						X	
Greenland	X						
Iceland	X						
Latvia				X			
Lithuania				X			
Norway			X				
Poland					X		
Sweden						X	

Table 1. The frequency and establishment of *Anguillicola crassus*, please refer also to the information provided for this species at www.nobanis.org/search.asp. Legend for this table: **Not found** –The species is not found in the country; **Not established** - The species has not formed self-reproducing populations (but is found as a casual or incidental species); **Rare** - Few sites where it is found in the country; **Local** - Locally abundant, many individuals in some areas of the country; **Common** - Many sites in the country; **Very common** - Many sites and many individuals; **Not known** – No information was available.

Ecology

Habitat description

Despite the fact that this is an introduced species, *A. crassus* has been able to find a range of suitable host organisms in its new environment. In addition to various species of marine and freshwater fishes, aquatic snails, amphibians and insects can serve as hosts for *A. crassus* (Moravec and Skorikova 1998). Intermediate hosts include copepods and ostracods (Bauer 1998). The European eel also seems to be more susceptible to the parasite than are their original hosts (Køie 1991). Once introduced into a lake or river it may spread rapidly among the eel population. *Anguillicola crassus* is a successful colonizer due to its large production of eggs and low specificity regarding intermediate hosts. Levels of infestation have been recorded to rise from 10% to 50% within a year (Belpaire *et al.* 1989, Koops and Hartmann 1989)

Laboratory investigations have shown that adult parasites and eggs can remain viable in seawater, although hatching off the egg is reduced. Survival of free-living larvae are maximal in freshwater but decline with increasing salinity (Kennedy and Fitch 1990). According to Svedäng (1996) the low number of infected eels on the Swedish west coast compared to the Baltic Sea supports the view that the spread of *A. crassus* is prevented by salinities above 8-10 psu. Infected paratenic hosts in brackish or marine environments, such as ruffe (*Gymnocephalus cernuus*), smelt (*Osmerus eperlanus*), and black goby (*Gobius niger*) can however serve as dispersal vectors in marine environments if they are consumed by eels. Other studies have shown that larval development is significantly retarded at low temperatures and that adult worms show increased mortality and decreased growth and reproduction at low temperatures (Knopf *et al.* 1998). According to Knopf *et al.* (1998) the latter supports the hypothesis that the spread of *A. crassus* in boreal regions is restricted by temperature regimes. On the other hand, increasing temperature will have a negative effect on the establishment of the parasites on intermediate hosts (copepods) (Ashworth *et al.* 1996).

Reproduction and life cycle

This parasite possess several attributes of a successful coloniser such as high dispersal ability, long survival of the free larval stage, high fecundity (large production of eggs), high reproductive rate, and great receptivity of host organisms (Ashworth and Blanc 1997).

A. crassus is ovoviviparous, *i.e.* the eggs are hatched inside the female. The first larval stage emerges within the swimbladder of the eel, where the larva matures to its second stage. By way of the pharynx, the larva reaches the eels' intestine through which it is excreted into the water. The second stage can survive for considerable time in the water, waiting to be consumed by a suitable paratenic or intermediate host, *e.g* a copepod. Various aquatic non-crustaceans invertebrates *i.e.* insects, snails, and vertebrates, amphibians and fish may act as intermediate hosts which are not needed for the development of the parasite, but nonetheless serve to maintain its lifecycle (paratenic hosts) (Kennedy and Finch 1990, Thomas and Ollevier 1992, Moravec and Skorikova 1998). The larvae migrate through the intestinal wall into the swimbladder. There they moult to fourth stage, then molt once again and develop into adults. The life-cycle can be completed in two months in the laboratory (De Charleroy *et al.* 1990).

There is no obvious seasonal cycle in either prevalence or mean intensity of *A.crassus* in the European eel (Thomas and Ollevier 1992, Kelly *et al.* 2000).

Dispersal and spread

In Denmark, as in most of Europe, this eel parasite occurs mainly in freshwater, but it is also found in the brackish Ringkøbing Fjord, which is also believed to be the first point of introduction (Køie 1991). In freshwater it is present *i.a.* in Jutland and on Zealand (Denmark). It is also present in the

Poland -Vistula Lagoon and the Pomeranian lakes (Grawinski 1994, Rolbiecki et al. 1996). In Sweden, the parasite is firmly established at several locations on the Swedish east coast (Svedäng 1996). It was first discovered in high numbers at sites affected by cooling water discharges from a nuclear power plant (Höglund and Thulin 1994, Höglund and Andersson 1993), but it is no longer limited to areas influenced by thermal discharges. Infected eels are also found along the Swedish west coast, but the levels of infestation are much lower (Svedäng 1996).

In Norway, infected eels have been caught just north of the Norwegian/Swedish border (Mo and Steien 1993). *A. crassus* is not present in Finnish inland waters according to Køie (1991). No further information on its presence (or absence) in Finland since the publication of that paper (1991) has been found.

Due to geothermal activity on Iceland, the all year temperature of some discrete small rivers/ponds is sufficiently warm to support the establishment of *A. crassus*. Icelands natural isolation acts as a barrier for a natural introduction of alien parasites (the prevention is not absolute as witnessed by the present freshwater fauna) (Kristmundsson 2006).

In cultured populations with high densities of eels 100% of the eels may be infected. This can also be the case in wild populations in inland waters (van Banning 1991). The level of infestation in marine and brackish waters seems to be lower, but levels of more than 60% have been reported from brackish waters in Sweden (Höglund *et al.* 1989).

The phenomenon that the prevalence and intensity of infection is high shortly after the introduction of a parasite in a water system followed by stabilization at a lower level has been observed for *A. crassus*. In Lake Arresø in Denmark the prevalence was 3-7% in 1987-1988 (Køie 1988, Boëtius 1989). In 1992 it was close to 100%, but in 2003 the prevalence was less than 50% (Køie, unpubl. obs.). The mean intensity of infection showed a similar development. A similar levelling off in the infection spread of *A. crassus* was found in a canal in southern France. Repeted infections might have made the swimbladder unsuitable for further *A. crassus* establishment (Lefebvre and Crivelli 2004)

Impact

Affected habitats and indigenous organisms
Adverse effects on wild and cultured eels may occur when the level of infestation is high. Damage caused through inflammation of the swimbladder and secondary bacterial infections may decrease growth and increase mortality in the eel (van Banning 1991).

Damage is caused both by larvae, which live in the tissue of the swimbladder, and adults and pre-adults, which suck the blood of the host. Pathological reactions of the tissues include inflammation, necrosis, and scarring. Of all eels examined in a two year German study, 28% showed pathological alterations of the swimbladder (Wurtz *et al.* 1998). Repeated infestations may eventually reduce the swimbladder to a “non-functional mass of tissues” (Hartmann and Nellen 1997). Concern has been raised that massive damage to the swimbladder may make the eels unable to migrate back to their breeding grounds in the Sargasso Sea. This could have a severe impact on the recruitment of eels and thus on the future of the European eel population (Hartmann and Nellen 1997).

Kelly *et al.* (2000) found that there were no major differences in hormonal, metabolic or osmoregulatory status of eels infected with up to 15 blood-feeding adults in the swimbladder lumen and up to 25 larvae in the swimbladder wall compared with wild uninfected eels. Gollock *et al.* (2005) found no significant changes in mean erythrocyte haemoglobin concentration in uninfected and infected eels. They suggested that acute temperature increase alone is unlikely to cause significant mortality of eels infected with *A. crassus*. However, the effects of chronic increases in temperature in combination with other factors such as toxicants and hypoxia are unknown. In lake Balaton, Hungary, mass mortality of eels infected with *A. crassus* was concluded to have resulted from high infection rates combined with high temperatures (Molnár *et al.* 1991).

The nematode can have negative effects on the condition of eels, especially those under stress. In cultured eels loss of appetite and vitality resulting in emaciation has been reported (van Banning 1991). Effects on wild populations are more difficult to study. Laboratory studies of stress factors that appear in the wild, such oxygen stress, may have a bearing on natural population as well. Experiments with decreasing oxygen levels have demonstrated that the eels most severely affected by anguillicolosis are the first to die, and the author concludes that infection by Anguillicola impairs the eels' natural resistance and, under unfavourable environmental conditions, may lead to their death (Molnár 1993). Loss of vitality may also lead to greater susceptibility to infections, and to an increased risk of being preyed upon.

Genetic effects
Not known.

Human health effects
Not known.

Economic and societal effects (positive/negative)
Infected eels have reduced swimming ability (Sprengel and Lüchtenberg 1991). It is thus likely that heavily infected eels have an increased risk of being preyed upon by *e.g.* cormorants.

The parasite has caused mortalities in Danish eel farms (Køie 1991). Even if the eels do not die, infection may cause a reduction of the growth rate, and thus in the economic output of the eel farms. It is unknown whether damage to the swimbladder may prevent the spawning migration to the Sargasso Sea. Uninfected eels are found in the marine environment, so *A. crassus* has probably only a limited effect, if any, on the European eel fisheries. Overfishing and pollution are greater risks.

Management approaches

Prevention methods
For cultured fish drug treatment, either by bathing the fish or administered with the feed, has been tested, with varying degrees of success (Taraschewski *et al.* 1988).

Eradication, control and monitoring efforts
Since dispersal by man has been identified as the main vector for the continued spread of *A. crassus* in Europe, monitoring and strict quarantine measures will be necessary to control its further spread. No dedicated programmes are running so far.

Information and awareness
This species presents a serious threat, therefore it is always in focus in the most scientific and popular publications relating to the general topic of invasive species and their spread in the Europe. However interested parties are mostly scientists and aquaculturists. Any information on further spread and development of prevalence and intensities of infection is of interest as well as observations on diseased eels in relation to their natural environment.

Knowledge and research
None.

Recommendations or comments from experts and local communities
Since spread between localities is generally through transport of infected eels, uncontrolled movements of infected eels should be avoided.

References and other resources

Contact persons

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Links

EELREP project papers and manuscripts

Aquatic alien species in German inland and coastal waters (database)

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